CSCI-8940: IDA-NET Objective Function
(Engineering Summary)

INPUT

Constants needed by the objective function:

Minimum NCs = 1;
Minimum SCCs = 1;

Corps NCs = 42;	Div NCs = 4;
Corps LENs = 9;	Div LENs = 1;
Corps SEN1s = 168;	Div SEN1s = 12;
Corps SEN2s = 56;	Div SEN2s = 4;
Corps SCCs = 7;	Div SCCs = 1;
Corps RAUs = 92;	Div RAUs = 9;
Corps NAIs = 4;	Div NAIs = 1;

NC wires = 24;
LEN wires = 176;
SEN1 wires = 26;
SEN2 wires = 41;

RAU links = 25; { plan for no more than 25 MSRTs }

Percent = 0.142857; { each component represents 1/7th }

Data needed by the objective function:

Number of MSRTs to support (type is integer)
Number of DNVTs to support (type is integer)

Individual (configuration solution) to be evaluated

OUTPUT

The fitness value for an individual (type is real).

PROCESS: Computing the terms and fitness

The objective function evaluates an individual solution based on 7 terms (type: real) that are then multiplied together to give a single value. The terms are: the cardinality of the individual, the SEN1 to SEN2 relationship term, the UHF connectivity term, a term for minimum constraint violations, a term for maximum constraint violations, a term for MSRT support, and a term for DNVT support.

The cardinality term (CT) gives higher term values to individuals with fewer components. Each component is scaled based on its component type. The sum of all component values is then divided into a constant value of 50.

$$CT = \frac{50}{\sum_{i=NC} \frac{component_i}{Corps_i} * percent}$$

The SEN1 to SEN2 relationship term is based on the notion that any network should have a 3-to-1 ratio of SEN1s to SEN2s. This produces networks with an optimal mix of these two types of components because of their support capabilities and resources required. If the number of SEN1s is greater than three times the number of SEN2s, then this term is the ratio of three times the number of SEN2s to the number of SEN1s. On the other hand, if the number of SEN1s is less than or equal to three times the number of SEN2s, then the term is the ratio of SEN1s to three times the number of SEN2s.

The UHF connectivity term deals with the capacity of the network when supporting the individual components, that is, we want to converge on networks that have a minimal amount of excess UHF antennas. Assuming that the network is feasible (does not violate either the minimum or maximum terms), we need to determine the number of antennas available in the network (the number of NCs times 12; recall that 12 is the number of antennas in a NC), and the number of antennas needed to support both the backbone components and the other components. If the difference between the available antennas and the antennas needed (available minus needed) is greater than 12, then the term is simply the number of antennas needed divided by the number of antennas available. Otherwise, the term has a value of one.

To determine the number of antennas needed to support the network, we need to know the number of antennas needed to connect the backbone (i.e., the NCs) and the number of antennas needed for the other (non-NC) components. The engineers have given us the following formula:

needed = total_available - available_from_backbone + others

"*others*" is just the number of other components times their number of antennas. The antennas value is one in every case except for LENs which have two. "*total_available*" is the number of NCs times 12. "*available_from_backbone*" is computed using:

*available_from_backbone = (32*Y) - (X*X) + (13*X)*

where

X = ((number_of_NCs - 1) mod 4) + 1
Y = (number_of_NCs - 1) div 4
Z = Y + 1 {to be used with maximum term later}

The minimum constraint violations term focuses on each network having at least one NC and one SCC. If either of these constraints is violated, then the minimum term is set to zero. Otherwise, it remains one.

The maximum constraint violations term insures that division component maximums are not violated. The maximum component type value is the division complement times *Z* computed earlier (e.g., maximum SEN1s would be 12 times *Z*). Therefore, if any component (LEN, SEN1, SEN2, RAU, NAI, SCC) exceeds its maximum, then the maximum term is set to zero. Also, if the number of antennas available is less than the number of antennas needed, the maximum term is set to zero. As with all the settable terms, if they are not set to zero, they maintain a value of one.

The MSRT support term and the DNVT support term are similar in that if the number of MSRTs or DNVTs to be supported can not be supported by the network, then either the MSRT support term is set to zero or the DNVT support term is set to zero (of course, both could be set to zero in cases where the network can not support either requirement). In the event that more MSRTs or DNVTs can be supported than are required, we introduce a penalty. Namely, if the number of MSRTs required is less than or equal to the number of MSRTs that can be supported, then the MSRT support term is equal to the ratio of required MSRTs to supported MSRTs. Note that when these two values are equal, the MSRT support term becomes one. The same scheme is used for the DNVT support term.

Finally, after each term is computed for the current individual, the terms are multiplied together giving a product value. This product is the fitness of the individual.

EXAMPLES

Required MSRTs: 672
Required DNVTs: 1495

Selected networks and fitness values

Fitness	NC	LEN	S1	S2	SCC	RAU	NAI
225.19250:	9	1	30	9	1	27	1
228.68143:	9	2	25	8	1	27	1
230.73248:	9	1	27	10	1	27	1
234.18020:	9	1	28	10	1	27	1
237.44941:	9	1	29	10	1	27	1
238.00433:	9	1	29	9	1	27	1
240.54973:	9	1	30	10	1	27	1
243.30832:	9	2	24	8	1	27	1